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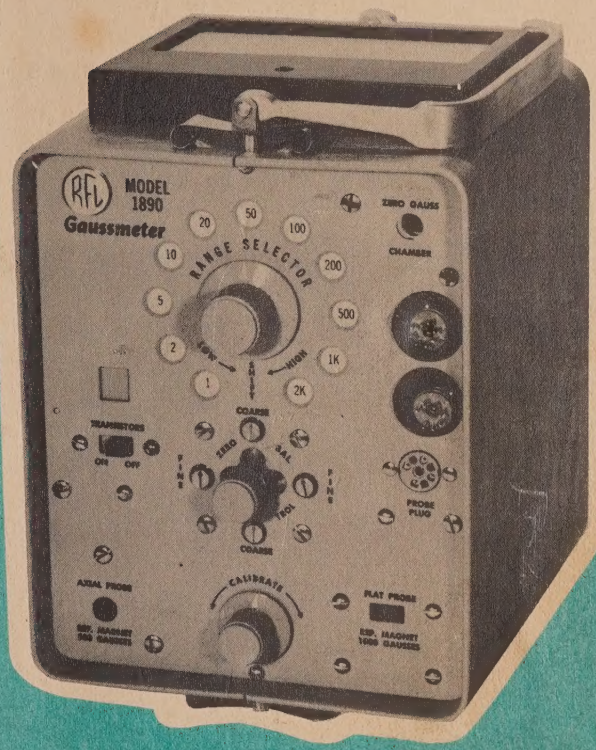
Manual of Instructions



Gaussmeter

Model 1890

Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

Designers and Manufacturers of Electronic Equipment since 1922

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SUPPLEMENT NO. 1
INSTRUCTION MANUAL

SUBJECT: MOST ACCURATE* MEASUREMENT OF MAGNETIC FIELDS FROM 10K TO 30K GAUSSES WITH MODEL 1890 GAUSSMETER

InAs elements are inherently non-linear in response over such a wide range as 0 to 30K gausses. Since elements differ with respect to where their linearity appears in their response curve, it is possible to select elements favoring linearity at higher or lower gauss levels, It should be noted, however, that the response of InAs drops fairly rapidly above 10K - 15K gausses, hence the requirement for calibration curves for accurate measurements above 10K gausses. This decrease in sensitivity permits measurements to be made to 30K gausses with the Model 1890 using the 20K gauss scale.

To increase the Model 1890 Gaussmeter's usefulness as an accurate measurement tool, two options are available (at extra cost) where requirement calls for utmost accuracy in measuring high gauss fields (these apply to flat probes only).

CALIBRATION OPTION "A":

Where magnetic field measurements are to be made from 10K to 20K gausses and utmost accuracy is required in this range, we can select and calibrate the probe and supply a curve of its performance from 5K to approximately 25K gausses. This curve will be in addition to the test data sheet normally supplied. This probe can also be used over the 1 to 10K gauss ranges and, using the standard 1000-gauss reference magnet, will yield a system accuracy* within ±3% from 1 to 20K gausses (using the calibration curve above 10K).

CALIBRATION OPTION "B":

Where accurate magnetic field measurements in the range of 20K to 30K gausses are desired, we can supply a selected and calibrated probe with a curve showing its performance from 5K to approximately 28K gausses. A standard 10K gauss reference magnet is required and, using the curve, the system accuracy* is within ±3% from 5K to 28K gausses.

NOTE: This probe is not calibrated below 5K gausses and, due to non-linear characteristics at lower ranges, its accuracy will decrease appreciably at lower field levels, (If user desires to make accurate measurements in the low ranges he would also require a standard flat probe and a 1000-gauss reference magnet).

* Our accuracy claims in print are conservatively stated as within ±3% to cover all conditions. Since every probe is individually calibrated and adjusted, the test data sheet supplied will show that accuracy on most ranges is well within ±2% and, in many cases within ±1%.

General Description

PURPOSE

The Model 1890 Gaussmeter was developed to measure magnetic fields between 0.1 and 20,000 gausses.

The equipment operates on the Hall Effect principle, enabling a measuring probe of small physical size to be used for measuring flux densities up to 20,000 gausses. The probe elements are constructed of A_{III}-B_V intermetallic compound semiconductor material with temperature stable Hall coefficients. The use of transistors throughout provides maximum temperature stability, reduces equipment warm-up time to a minimum, and permits economical battery operation for portable or field use in addition to AC line operation.

The Model 1890 provides a rapid means of checking magnetic instruments at any stage of their assembly. It is a complete instrument for making direct measurements of gap flux density in normal or axial fields, and analyzing location, homogeneity and intensity of stray fields. It permits both quantitative and qualitative checking of design formula predictions.

DESCRIPTION

The equipment is enclosed in a gray vinyl covered aluminum cabinet measuring 8-1/2 inches high by 6-3/4 inches wide by 8 inches deep, and weighs 12 pounds. All operating controls are located on the front panel as shown in Figure 1. The large meter, calibrated directly in gausses, is mounted in the top panel, as shown in Figure 3, and can be raised to four positions (horizontal, 48°, 61° and 73°) for easy reading from the front of the instrument or removed and placed in the work area as shown in Figure 4. For this facility the meter is a core magnet type, equipped with mirror scale and knife edge pointer, producing practically no stray fields to affect measurements made close to it. The meter mechanism provides better than 0.5% repeatability, while its long scale and linear divisions allow for better than .01 gauss resolution of reading on the lowest scale.

Seven control functions are accomplished through operation of only three knobs mounted on the front panel. These controls are the ZERO BAL. CONTROL, CALIBRATE and the RANGE SELECTOR switch which provides a selection

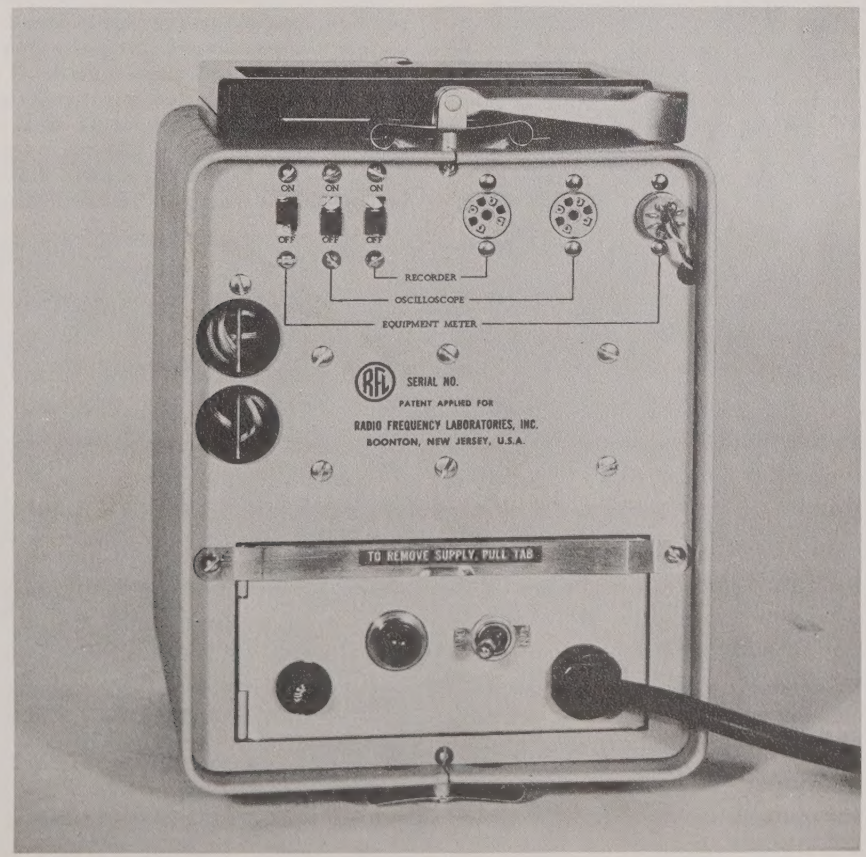


Figure 2. Rear View of Model 1890 Gaussmeter with AC Power Supply.

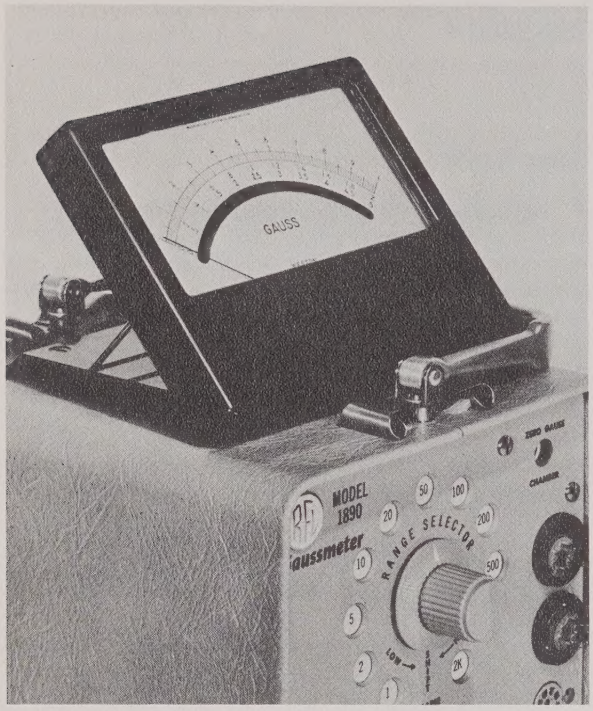


Figure 3.
Meter on Model 1890.

of fourteen, overlapping full-scale ranges divided into two groups: a LOW of eleven ranges from 1 gauss to 2000 gausses and a HIGH of eleven ranges from 10 gausses to 20,000 gausses. Range switch settings are in two colors: black for LOW, red for HIGH. Each range position is indicated in digits for error-free selection of full-scale sensitivity desired. (See Figure 11.) The shift from LOW to HIGH is easily made by turning the RANGE SELECTOR to the full bottom position, going counterclockwise for LOW shift or clockwise for HIGH shift. The scale will shift showing red or black digits for the ranges required.

Space is provided for two reference magnets inside the cabinet. These magnets are mounted on the back of the front panel with access from the front. One is for calibrating flat probes up to .050 inches thick at a value of 1000 gausses $\pm$0.75%. The other calibrates axial probes at 500 gausses $\pm$1.5% and is included as part of the axial probe set. To provide accurate zero setting of both probes, a shielded Mu-metal cavity (ZERO GAUSS CHAMBER) is provided and is also accessible through the front panel so that stray magnetic fields, including the earth's field, can be prevented from affecting the zero balance. As shown in Figure 6, the ZERO GAUSS CHAMBER, FLAT PROBE REFERENCE MAGNET, and AXIAL PROBE REFERENCE MAGNET are held in place by flexible bands and can be removed easily to be placed on the work surface in front of or beside the Gaussmeter, whichever is most convenient.

Space is provided for storing two probes inside the unit with access through the front panel for convenience.

Basically, the Model 1890 consists of a power supply (AC or battery), a probe 3000 cps. transistor oscillator, a range switch attenuator, a 3000 cps. filter, a stabilized transistor amplifier, meter and a measuring probe. The circuitry is divided into major functions and packaged in separate, modular units. The 3000 cps. oscillator feeds current to the semiconductor probe element. The current is held constant at all times. Potential leads are connected across the element and, when the surface of the element is placed at an angle to a magnetic field, a difference of e. m. f. will take place between the potential contacts. This output voltage is proportional to the intensity of the magnetic field and, after passing through

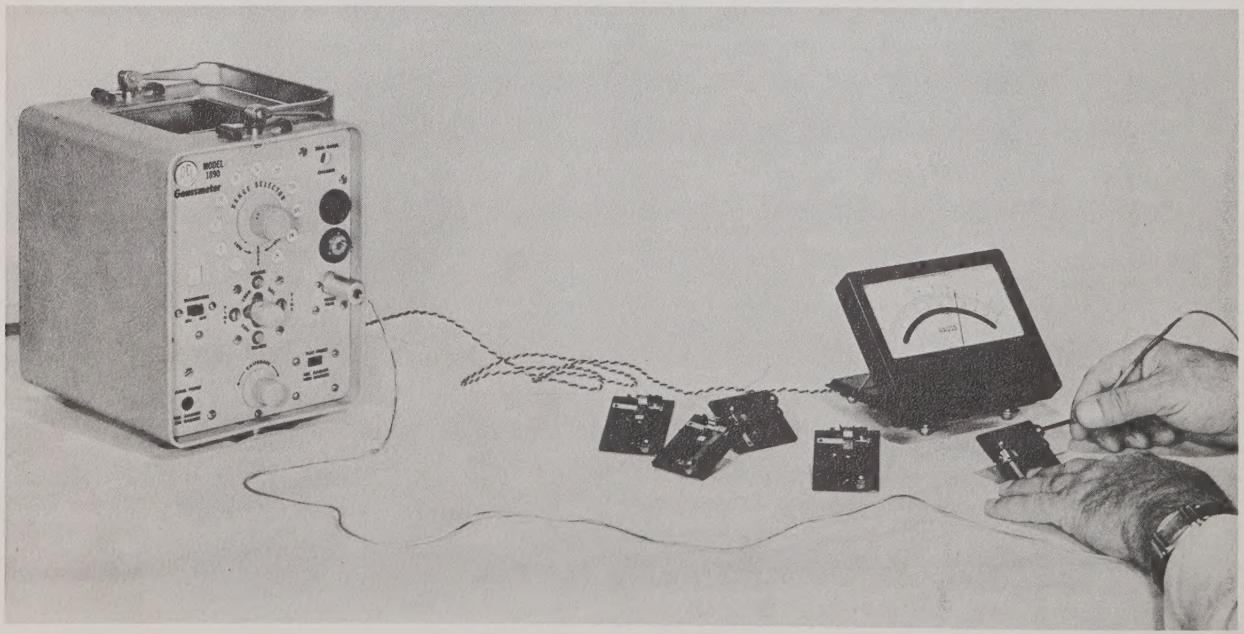


Figure 4. The Meter of Model 1890 Removed from Cabinet.

a harmonic filter, is applied to the range attenuator. The resultant voltage is then amplified and, after being rectified to DC, appears across the meter. A balancing circuit, consisting of four potentiometers, controlled by one knob, sets the residual e. m. f. to read zero on the meter when the probe is in the ZERO GAUSS CHAMBER. A CALIBRATE control is provided on the front panel to set the calibration when the probe is inserted in a reference magnet field. Each Model 1890 is supplied with an RFL certified calibration record on all full-scale points based upon the 1000-gauss reference magnet. Down-scale readings are supplied on the 10,000 and 20,000-gauss ranges to allow for correction of non-linearity of the Hall coefficient on these ranges.

For research work and special applications, the oscillator output transformer and the amplifier input filter are provided with a series of taps which permit 2 to 50 ohms adjustment to various probe impedances. These taps are push-pin connections (see Figure 19) and, by making these adjustments, engineers can use the Model 1890 to measure the Hall coefficients of materials at low field intensities. These facilities also prevent the instrument from becoming obsolete as improved Hall Effect materials are discovered. The unitized construction allows the use of subassemblies for research projects.

The Gaussmeter amplifier is linear and powerful enough to drive an external recorder. There are three output plugs on the back panel, as shown in Figure 2, for an external recorder, oscilloscope and meter. These plugs can be switched consecutively into Gaussmeter circuit by the three slide switches on the back panel.

REFERENCE MAGNETS

A 500-gauss (±1.5%) axial reference magnet and/or a 1000-gauss (±0.75%) flat probe reference magnet are normally supplied with each probe type. Accurately calibrated permanent reference magnets may also be ordered at values between 200 and 10,000 gausses. (See Figure 5.) All reference magnets are stabilized and adjusted using mutual inductors and search coils with Bureau of Standards certificates.

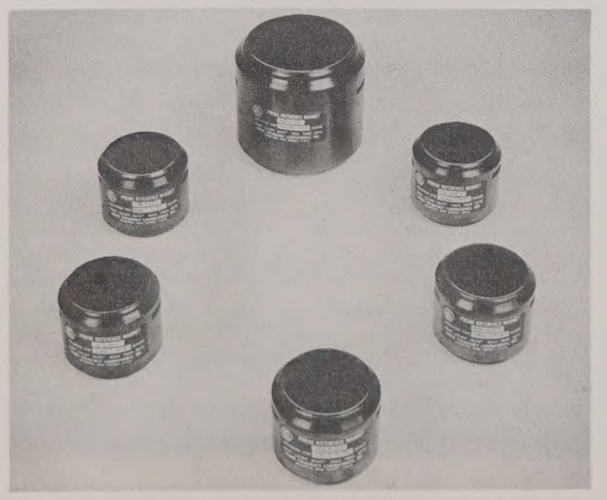


Figure 5. View of Reference Magnets for Flat Probes.

The reference magnets are co-axial in form to eliminate stray fields in the area of measurement and to provide against possible magnetic change in the reference when contacting other strong magnets. The pole faces are accurately machined of special alloys to provide a uniform flux distribution. The accuracy of magnets between 1000 and 10,000 gausses is measured to be within ±3/4% of the absolute value of gausses specified. Between 200 and 900 gausses, the accuracy averages ±1.5%. Below 100 gausses a precision solenoid may be used as a reference standard. Table 1 shows the approximate errors involved in the standardization of a ±3/4% reference magnet.

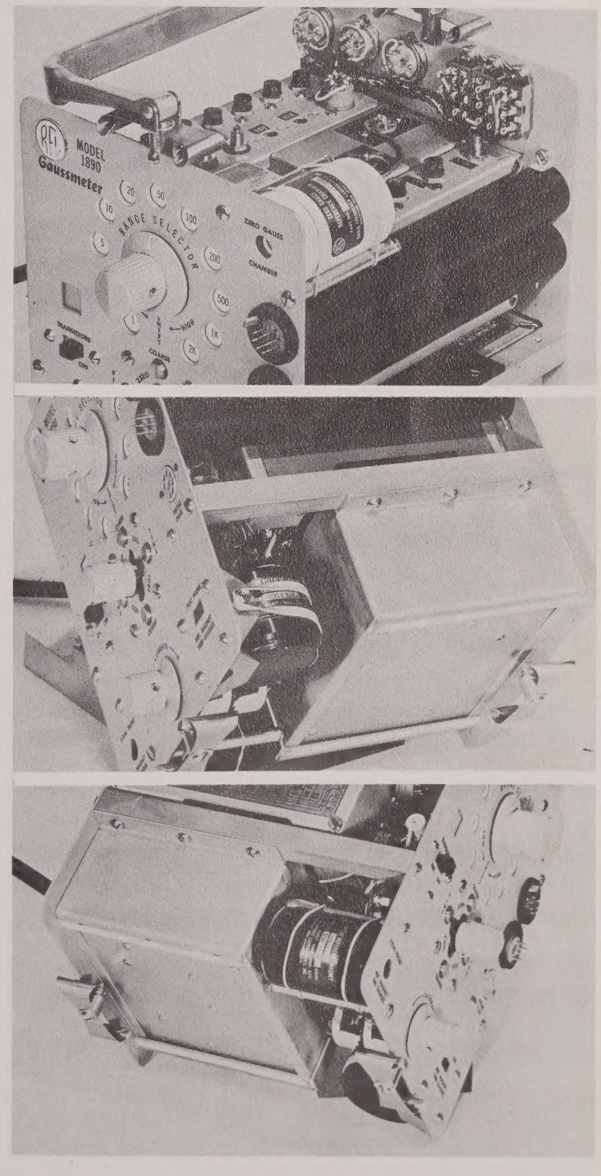


Figure 6.
Zero Gauss Chamber,
Flat Probe Reference Magnet
and Axial Probe Reference Magnet.

Table I.

Limits of Error in the Calibration of a ±3/4% Reference Magnet.

Error	Description
±0.25%	Bureau of Standards accuracy of calibration of search coil.
±0.05%	Bureau of Standards accuracy of measurement of mutual inductor.
±0.10%	RFL accuracy of measurement of DC current.
±0.20%	RFL fluxmeter transfer reading error.
±0.15%	Non-uniformity of field in gap.
±0.75%	Maximum error.

PROBES

Probes are constructed of InAs elements 1/16" wide by 3/16" long. One type is flat with a flexible shank as shown in Figure 8, for measuring fields perpendicular to its flat tip blade which is 13/64" wide by .025" thick. The same probe can be provided .035" thick at no additional cost for considerable greater strength for those whose purpose is general measurement in wider air gaps. The other probe, shown in Figure 9, is the "axial" type for measuring fields parallel to the stem of the probe. Its diameter is held to 5/16" ±.005". Both probes are constructed of glass reinforced epoxy and are safe for use around exposed low voltage electrical connections.

POWER SUPPLIES

The equipment is supplied, as ordered, for battery or AC line operation.

The Battery Supply HB-13,375 and the AC Power Supply HB-13,350 are the same size, see Figure 10, and are easily installed or exchanged without tools. For normal laboratory or field use, battery operation is most convenient. For continuous laboratory or production use, the AC power supply is recommended.

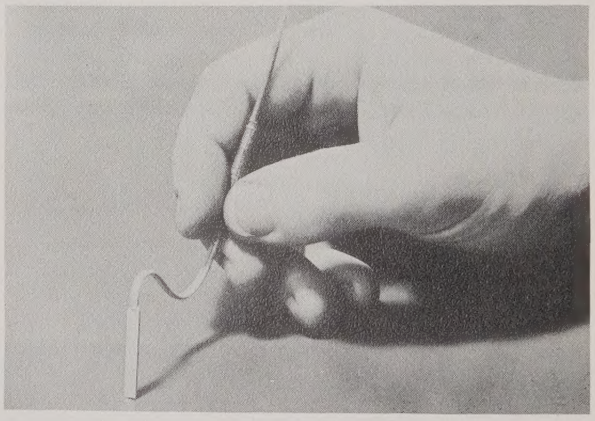


Figure 8.
InAs Flat Probe Showing Flexibility.

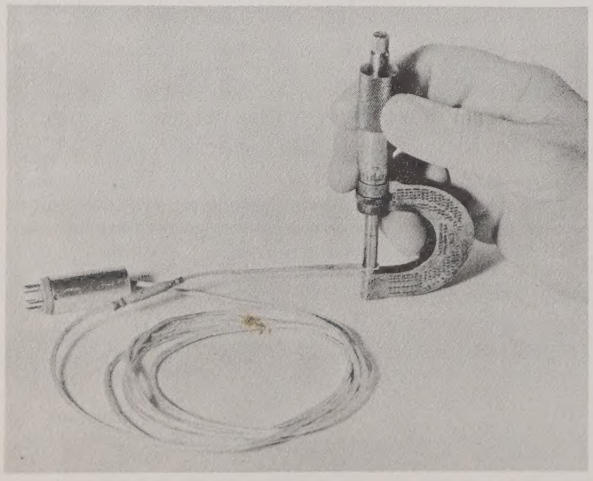


Figure 7.
InAs Flat Probe .025" or .035" thick.

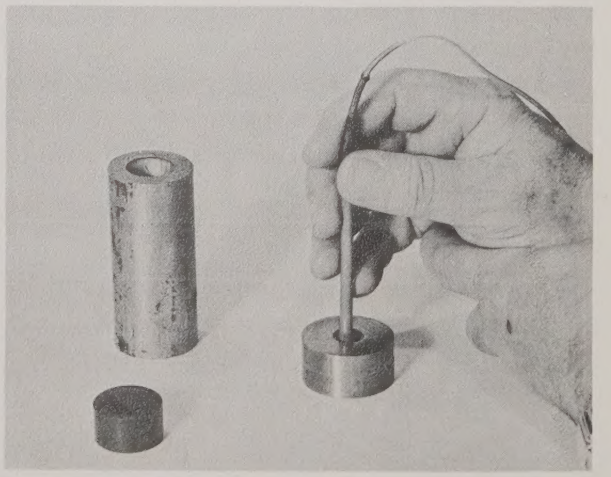


Figure 9.
InAs Axial Probe.

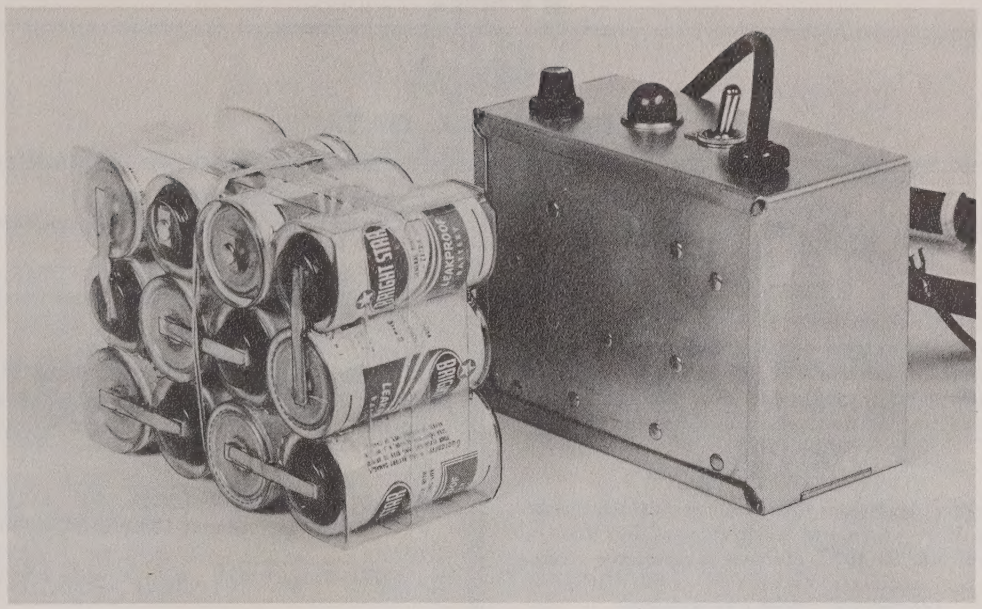


Figure 10. Battery Power Supply HB-13, 375 and AC Power Supply HB-13, 350.

Battery Supply HB-13, 375: Holds 12 standard D-size, 1. 5-volt flashlight cells (supplied) which provide more than 100 hours of intermittent 4-hour per day operation.

AC Power Supply HB-13, 350: 115 volts, 50/60 cps. , 3 watts. Output 18 volts DC at 18 MA. Internal connections may be changed for 230 v, 50 cycle operations.

Installation and Operation

UNPACKING THE EQUIPMENT

For shipment in the continental United States, the equipment is packed in commercial cardboard cartons. Upon receipt of the equipment, the unit should be removed from the packing case and inspected for damage in shipment.

The case of the Gaussmeter is in two halves; they are identical and can be interchanged. Four double-ended butterfly type springs hold the case halves, both together and separately, in the front and rear panels. The meter and its easel mount are held on the top of the case by either or both of the case halves. To remove, place the Gaussmeter flat on its right side and lift up the left case half, top and bottom evenly, as shown in Figure 13. The meter and its easel will remain in the right case half as shown. Figure 14 shows the next step with the meter withdrawn and also the meter tray. This meter tray not

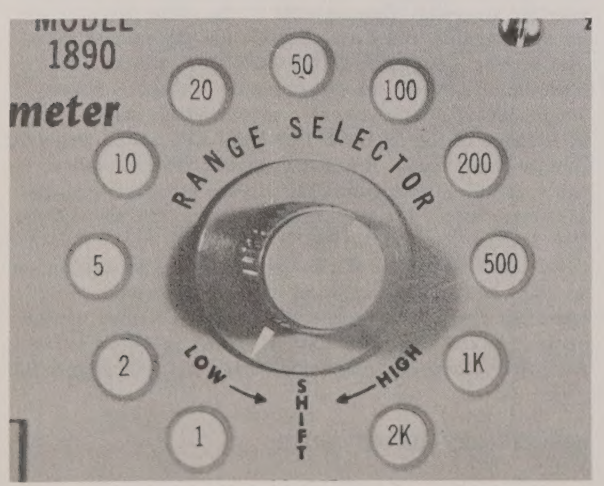


Figure 11. Range Selector.

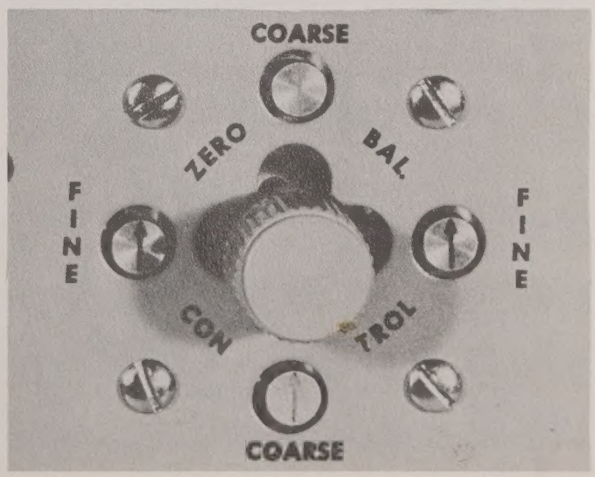


Figure 12. Zero Bal. Control.

Table 2.

TECHNICAL DATA

RANGES

0 to 1, 2, 5, 10, 20, 50, 100, 200, 500, 1K, 2K, 5K, 10K and 20K gausses full scale.

ACCURACY

Overall system accuracy varies with probe type, range of measurement and reference magnet value employed - in no case is it less than ±3%. Ultimate accuracy on many ranges can be within ±1% using reference magnets and optional calibration data available.

TEMPERATURE STABILITY

Temperature deviations with InAs probes supplied are less than 0.5% change of sensitivity and less than 0.2 gauss zero shift for 10°C element temperature change.

MAGNETIC FIELD FREQUENCY

Magnetic fields from DC to 400 cps. can be measured.

OSCILLOSCOPE OUTPUT

2.0 volts max.; display includes 3000 cps. carrier signal.

EXTERNAL RECORDER OUTPUT

1.0 milliampere DC into 1500 ohms maximum.

SUPPLY VOLTAGE

With Battery Supply HB-13,375: Holds 12 standard D-size, 1.5 volt flashlight cells (supplied) which provide more than 100 hours of intermittent 4-hour per day operation.

With AC Power Supply HB-13,350: 115/230 volts, 50/60 cps. Output 18 volts DC at 18 MA.

SIZE: 8-1/2" high x 6-3/4" wide x 8" deep.

WEIGHT: 12 lbs.

only stores the extra cables and protects the Gaussmeter interior when used with the meter in remote location but, most important, it shields the amplifier transistors from the output meter leads when the meter is installed in the top of the Gaussmeter. Be sure it is properly in place when returning the meter to its mounted position. Grommets are provided on the meter cable to fit the slots cut in the tray and the back panel so that the cable may be entirely removed and the case fully closed without the meter. The case may also be closed with meter external and the Gaussmeter operated without the tray when its use requires frequent access to the controls, adjustments, and taps of the oscillator, filter and amplifier within.

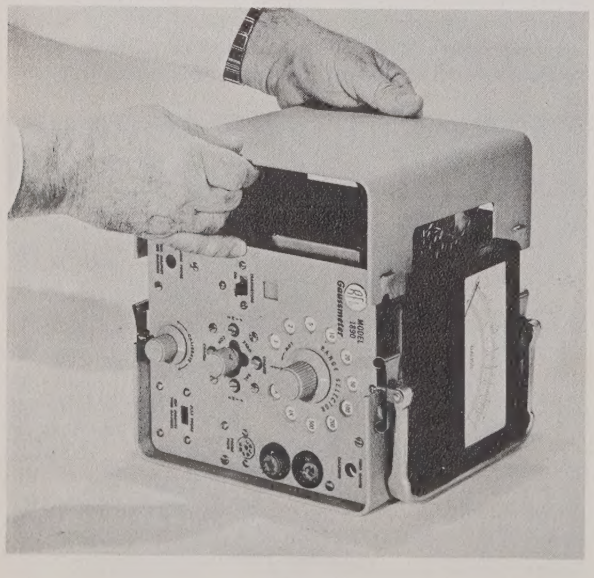


Figure 13.
Case Removal, First Step in Opening Case.

No tools are needed to remove or change power supplies. With the fingernail, lift out the tab as marked on the center of the retaining spring, see Figure 15, and the right-hand end of the spring can be disengaged from under the mounting screw. The retaining spring will then turn up, hinging on the left-hand mounting screw, out of the way. The power supply can then be pulled out. When plugging in the battery supply, it is important to note that the terminal contacts are UP so that contact with the top mounted springs within the Gaussmeter will provide connection.

POWER SOURCE

The equipment will operate either on 115-volt, 50/60-cycle power supply or from a battery supply. These supplies are small plug-in units of the same size and are interchangeable and easily installed at the rear of the Gaussmeter. A TRANSISTORS ON-OFF switch on the front panel is used with either supply. The AC Power Supply HB-13,350 has its own switch which may be used in addition to the TRANSISTORS ON-OFF switch when AC line supply is used. Approved three-conductor power cable and plug with grounding pin are provided with the AC power supply for proper connection to the power line. The Battery Supply HB-13,375 is supplied with twelve (12) size D, 1.5-volt dry cells and will operate the equipment for more than 100 hours at an intermittent service of 4 hours per day. At any time the transformer may be connected for 230 volts operation as shown in sketch of the AC Power Supply on Schematic Wiring Diagram Figure 23.

PRELIMINARY ADJUSTMENTS

Using the HB-13,350 AC Power Supply, plug the equipment into an AC line. Turn on both the line switch S5 on

HALL PROBE TEST DATA /

MODEL 1890 GAUSSMETER

Probe Type and Drawing No. HB-13460 for use on Gaussmeter No. 481

Probe Serial No. 1547

Resistor R_A 15 ohms

Resistor R_B 0 ohms

Filter Tap 5 ohms

Oscillator Tap 5 ohms

Probe Resistance

R_I (Pin 1 to Pin 3) 3.6 ohms

R_H (Pin 5 to Pin 7) 1.6 ohms

Drive Voltage Across Probe .162

Approximate Calibration Control Setting 3.0
(full clockwise rotation = 10)

Noise Level 1.0
(meter divisions on 1 gauss range)

Temperature Stability 1.0
(gauss/10°C)

Probe Sensitivity .086 (volts per kilogauss at Filter Output (measured at pin #1 of SP-3 with Drive Voltage preset to 0.1 volt across 2-ohm resistor.)

The following measurements were made on the Model 1890 Gaussmeter Serial No. 481. Axial probe data above 100 gausses was taken before the final molding process on a standard Model 1890 Gaussmeter and may deviate ±2% from the values given.

Standard Field Gauss & Range	Low Range Full-Scale Reading 1 to 2000 G	High Range Full-Scale Reading 10 to 20,000 G
1	98.5	
2	98.7	
5	98.0	
10	98.5	100.5
20	98.5	100.0
50	98.0	99.0
100	99.0	100.2
200	102.0	102.2
500	101.0	100.2
1,000	100.0	100.0
2,000	101.0	102.0
5,000		102.0
10,000		98.5
20,000		77.5

Down-Scale Reading 10,000-Gauss Range

Standard Field Gauss	Scale Reading
2,000	20.0
5,000	51.0
8,000	79.8
10,000	98.5

Down-Scale Reading 20,000-Gauss Range

Standard Field Gauss	Scale Reading
5,000	25.0
10,000	49.0
15,000	—
20,000	77.5

By Leon N. Squiers Date 4-12-62

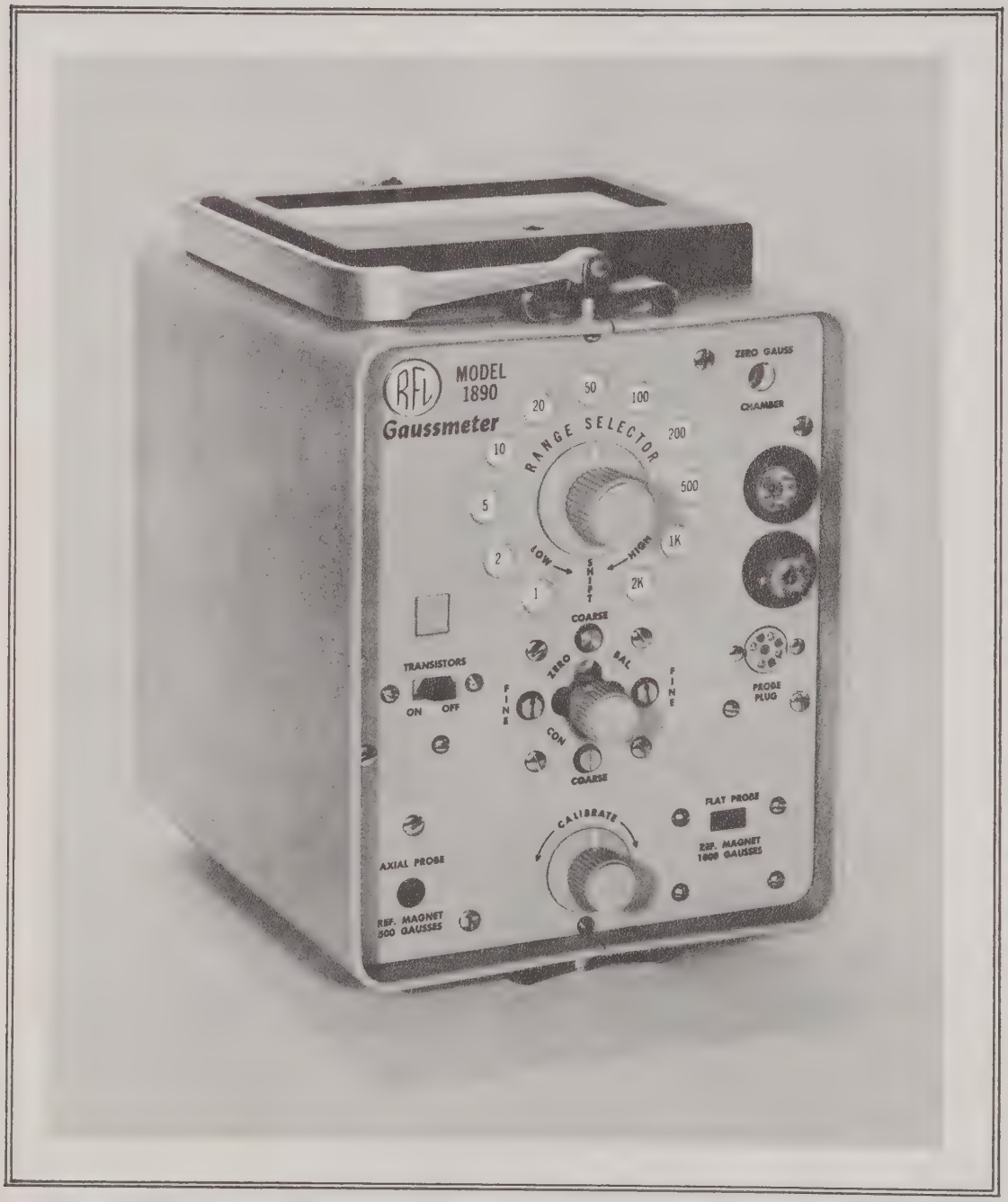


Figure 1.
Front View of Model 1890 Gaussmeter.

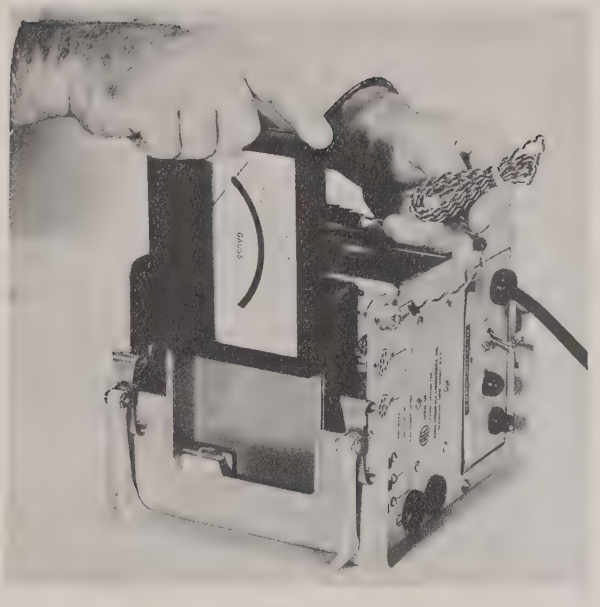


Figure 14.
Meter Assembly Slipped Out.

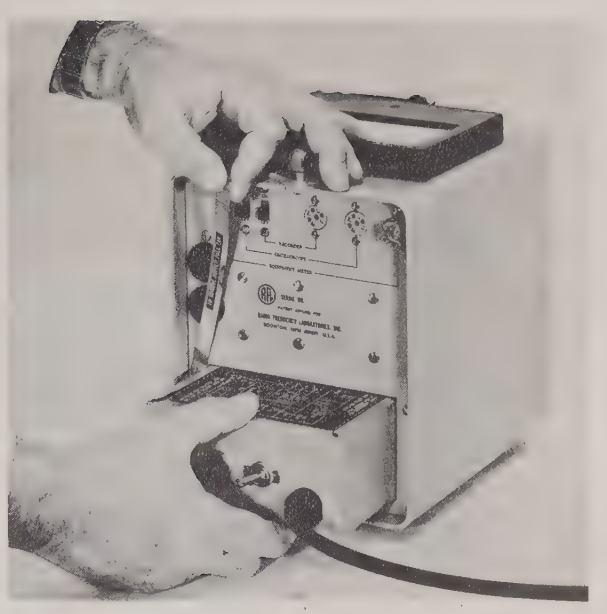


Figure 15.
Removal of Power Supply.

the power supply and the TRANSISTORS ON-OFF switch S1 on the front panel. Plug the probe into socket SP10 marked PROBE PLUG. Set the RANGE SELECTOR S4 to 1000 gausses on the red scales. Test the equipment by placing probe in the proper reference magnet for general operation and adjust the CALIBRATE control for full scale. Place the probe into the ZERO GAUSS CHAMBER and adjust the ZERO BAL. CONTROL for zero of the meter as described below. All four zero balancing functions are controlled by one 4-way knob, as shown in Figure 12, that disengages upon release so that accidental disturbance of a balanced condition is unlikely after adjustment is made. To engage knob, slide to left, right, up or down as needed. Set the RANGE SELECTOR to 100 gausses. Set all the small potentiometer shaft arrows vertical, then start with the upper COARSE potentiometer and engage its shaft and adjust the meter for a minimum meter reading. Next go to the lower COARSE potentiometer and again adjust for a yet lower meter reading. Increase the sensitivity to 10 gausses full scale and alternate back and forth between these zeroing controls until the null is below 1 gauss. Set the RANGE SELECTOR to 1 gauss full scale (back scales), see Figure 11, and complete the zeroing operation using the right and left FINE controls. The final zero should be within 4 divisions (.04 gauss) of zero. This zero represents thermal noise in the Hall element and base electrode of the first transistor and does not enter into the accuracy of the measurement above 20 divisions. In general, use the red scales for measurements above 10 gausses and the black scales below 10 gausses. The equipment must be calibrated at full scale with the reference magnet on the black scales or on the red scales whichever scales the final measurements are to be taken on. A full-scale calibration on the black scale may not hold on the red and vice versa. Full-scale calibration for flat probe is accomplished by placing the probe in the FLAT PROBE REF. MAGNET slot on the front panel with the RANGE SELECTOR switch placed at 1000 gausses. Locate the region of maximum field in the magnet and then adjust the CALIBRATE control for full-scale deflection. When the axial probe is calibrated in the AXIAL PROBE REF. MAGNET the maximum peak field in the center of the cavity is used to calibrate the probe at 500 gausses.

OPERATION

To operate the Model 1890 Gaussmeter

1. Plug in the line cord to a 115-volt, 50/60 cycle source and turn ON the rear power switch on the AC power supply and the TRANSISTORS switch on the front panel. Raise the meter for front operation.

2. Place probe in the ZERO GAUSS CHAMBER and check meter zero on the 1 gauss range. Readjust using ZERO BAL. CONTROL.

3. Set RANGE SELECTOR switch to full scale of the reference magnet using the red or black scales as the final measurement requires. Do not shift scales after this point.

4. Insert the probe in the reference magnet and adjust the CALIBRATE control for exact reading given on the magnet. The probe should be held free in the gap.

5. Reverse (turn over) the probe in the gap and note reading. Select the greatest reading and readjust the CALIBRATE control for full-scale reading.

6. Insert the probe perpendicularly into the field to be measured and change the RANGE SELECTOR switch to give the greatest on-scale reading. Reverse the probe and select the greatest reading. Record this reading in gausses.

7. If an accuracy of greater than 3% is required, the reading may be corrected with the probe

calibration data. The ultimate accuracy obtainable is in the order of ±1% to ±2% using a reference magnet whose value corresponds to full scale reading of the range being used.

8. If an external 1 MA recorder is used in lieu of the meter, the RECORDER switch S7 is turned on and an extension cable taken from the storage tray under the meter mounting. This cable is plugged into the rear RECORDER socket and the recorder connected across it.

9. For oscilloscope output the OSCILLOSCOPE switch S3 is turned on and an extension cable plugged into the OSCILLOSCOPE socket. Pin 7 of SP12 is the ground side.

10. Turn OFF the equipment by switching off the rear switch on the AC power supply and the front panel TRANSISTORS ON-OFF switch. When the battery power supply is used the TRANSISTORS ON-OFF switch controls the total battery drain.

Theory of Operation

THE HALL EFFECT

The Hall Effect occurs when a thin strip of metal or semiconductor is placed in a magnetic field as shown in Figure 17 with current flowing from end to end of the strip and the magnetic field perpendicular to the strip.

The magnetic field tends to cause the electrons in the strip to travel in curved paths, thus charging up the sides of the conductor until the transverse electric field exists of the right magnitude to cancel the effect of the magnetic field and make the electrons travel through the solid undeviated. The magnitude of this potential in volts is given by the equation:

$$E = \frac{RIH}{t}$$

where I is the current in amperes, H is the magnetic field strength in gausses, t is the thickness of the sample in centimeters, and R is the Hall coefficient in volt-cm/ampere gauss. Under the conditions shown in Figure 17, the terminal B will be negative with respect to terminal A for metals and semiconductors in which the current is carried by electrons. Reversing the field reverses the output polarity. As shown by the equation above, the width of the strip is not a factor of the output as long as it is large compared to the thickness. The strip should be twice as long as it is wide or the output drops off. For thin strips the output is unaffected by the frequency of the current of field in the audio range. Practical materials for Hall elements are films and slabs of specially refined semiconductors. The sensitivity, temperature stability and linearity to fields can be varied through wide ranges by selection of materials. One characteristic can usually be improved at the expense of the other characteristics. Hall elements made of InAs, InSb and other similar III-V compounds require a loading resistor across the Hall contacts for best linearity in strong fields above 2000 gausses. This resistor is determined experimentally for each element.

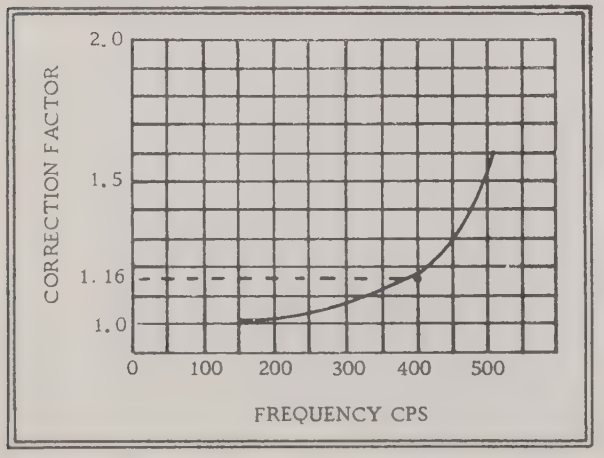


Figure 16.
Frequency Response of Model 1890 Gaussmeter.

CAUTION

InAs elements are brittle, are easily fractured if probe tip is bent, squeezed or flexed. Damaged probes will not be replaced under the equipment warranty.

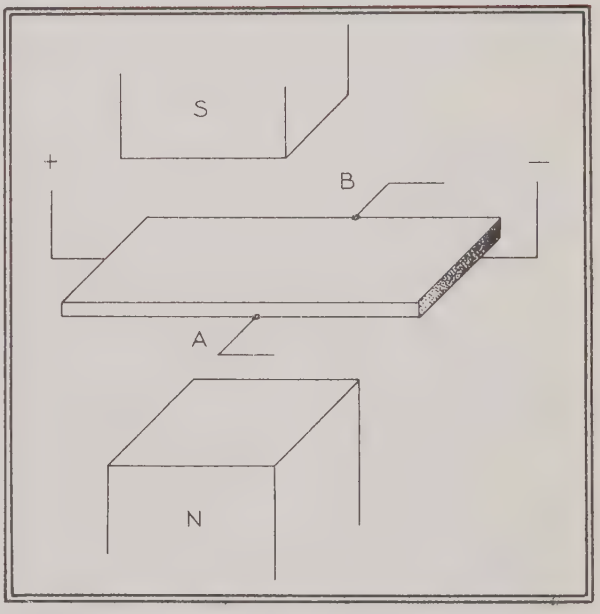


Figure 17.
Schematic Circuit Arrangement for the Measurement of the Hall Coefficient.

The flat and axial probes of the Model 1890 Gaussmeter are manufactured using a very thin piece of InAs 1/16 inch wide by 3/16 inch long. The InAs material used is selected for use in the temperature range of 32°F to 165°F.

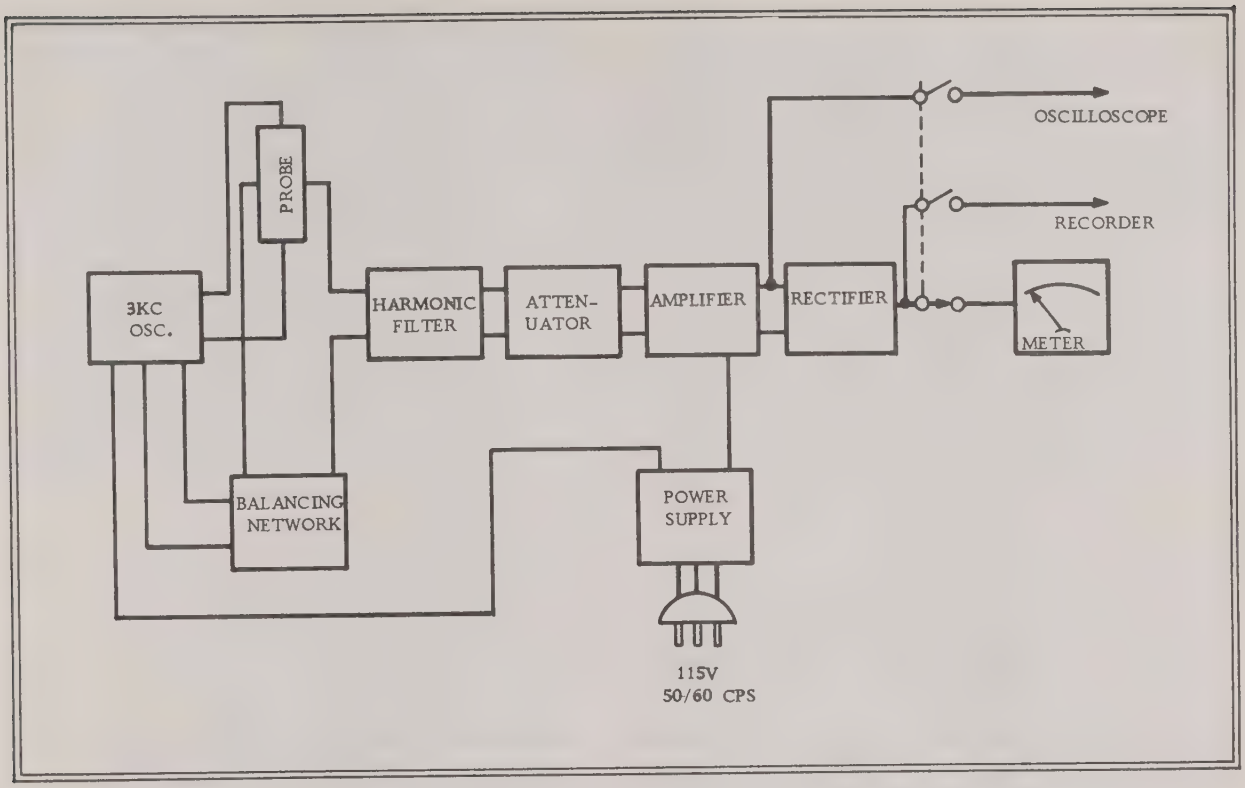


Figure 18. Block Diagram of Model 1890 Gaussmeter.

THEORY

The block diagram of Figure 18 shows the arrangement of circuits in the equipment. The 3000-cycle oscillator is designed to supply a constant current to the current terminals of the probe element. The potential leads are brought from the probe to a 3000-cycle filter with a 1000-cycle bandwidth. A balancing network is provided to inject a small voltage into the pickup loop to balance out the residual resistive unbalance in the probe. The ZERO BAL. CONTROL on the front panel adjusts the phase and magnitude of this injected voltage. The purpose of the filter is to remove harmonic voltage from the signal as generated in the 3-kilocycle oscillator and step the voltage up by a factor of ten. An 11-step attenuator permits measurements from 0.1 gauss to 20,000 gausses. The signal is amplified and rectified to operate the meter or external recorder. The final stage uses current feedback to improve the linearity of the meter rectifiers and is powerful enough to drive many DC recorders directly without further amplification. The over-all sensitivity is varied with a front panel CALIBRATE control. A regulated power supply provides the necessary DC power voltage. Semiconductor devices are used for rectification and amplification in all circuits.

AC FIELDS

When the probe is placed in an AC magnetic field the meter reads the average value of the field. The frequency response is shown in Figure 16 for a sine wave variation. If the wave shape of the field is of interest a rear panel OSCILLOSCOPE switch is provided to switch the rectifier and meter out of the circuit and substitute a 2.2K resistor R75 for an output load. The oscilloscope output is taken across this resistor and displays the carrier and its envelope. The peak signal can be set at 2 volts for full scale. The output may be termed as double sideband with suppressed carrier.

TEMPERATURE EFFECTS

As the semiconductor material has a temperature coefficient of resistance about the same as copper, the resistive zero balance of the probe is sensitive to temperature. The zero shift is, of course, greatest on the sensitive 1 gauss range. When the ambient temperature of the probe is changed, the zero should be checked and reset. The zero shift is less than 0.2 gauss for a 10°C change of temperature on the probe.

The Hall coefficient of the InAs material also changes with ambient temperature. The sensitivity of the probe may change approximately 0.05%/°C when submitted to ambient variations after calibrating with a reference magnet. The reference magnets change approximately 0.02%/°C; the magnet will return to its original calibration when normal temperature is restored. An ambient temperature above 180°F may permanently change the calibration of the magnet. A variation in ambient temperature also changes the rectification efficiency of the diodes in the meter circuit. These changes are normally eliminated by calibration at the temperature of use.

Maintenance

CALIBRATION PROCEDURE

Oscillator - HB-13, 385 -As shown in the schematic diagram (foldout at end of book), the oscillator coil L2 has a multi-tap secondary for matching into the current terminals of the Hall element. The position of the pin in SP7 and the matching impedance is given in the test data for each probe. This pin is usually in the 2-ohm tap. The adjustment of the oscillator consists of setting the OSC. GAIN control on the oscillator unit for the specified output or drive voltage across terminals SP10-3 and SP10-1 with the probe in the circuit. For the usual 2-ohm InAs probe this voltage is in the order of 0. 1 volt. The nominal resistance of InAs probes is 2 ohms between the current leads an 1 ohm between the Hall contacts. The 3000 cps. current through the current contacts is, therefore, approximately . 050 amperes. Figure 19 shows a top view of the Model 1890 Gaussmeter showing the location of subunits. Figure 20 shows location of sockets on the Oscillator HB-13, 385.

Hall Probe Elements - Load resistors when required for best linearity to strong fields are determined for each Hall probe and mounted in the connector plug. (See Schematic Diagram.) The procedure for determining the load resistor for a Hall element is to connect a variable resistance box across pins 5 and 7 of socket SP10 (see Schematic Diagram of Figure 23) and adjust the resistance of the box so that full scale readings on the 1000, 2000, 5000 and 10,000-gauss ranges are within 2% of the full-scale mark. This requires probe reference magnets at the above values. With the probe unloaded, the readings at 5000 and 10,000 gausses will be high by about 4% to 8% when the instrument has been initially set at 1000 gausses. As the shunting resistor is changed, the CALIBRATE control must be reset at 1000 gausses.

A resistive value is selected that places the 5000-gauss range 1% to 2% high and the 10,000-gauss range about 1% low. The value so obtained is Ra and is soldered across pins 5 and 7 of plug P10. A resistor in position Rb may be used to further improve linearity. For most RFL InAs probes this loading resistor varies between 1 ohm and 2 ohms when the probe is driven from the 2-ohm tap on the oscillator output transformer and the input impedance tap to the filter is set at 5 ohms. The internal driving impedance of the oscillator affects the linearity of the elements and in general should be kept high by using the

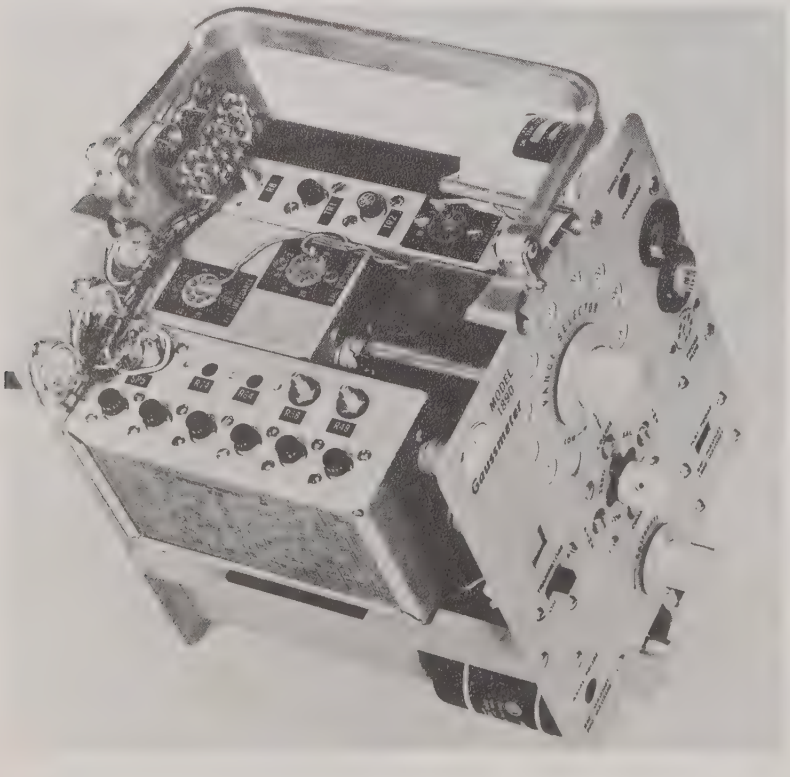


Figure 19.
Top View of
Model 1890 Gaussmeter
Showing Location of Subassemblies.

NOTE

In some cases, damaged probes can still be used on the higher ranges. If partial fracture of the element has occurred, the probe cannot be zero balanced to any useful accuracy on the low ranges but, by checking its zero balance on higher ranges, it can be determined if it will yield useful readings at higher gauss levels. The scale reading above zero to which it can be balanced on a given range will indicate the accuracy of reading on that range.

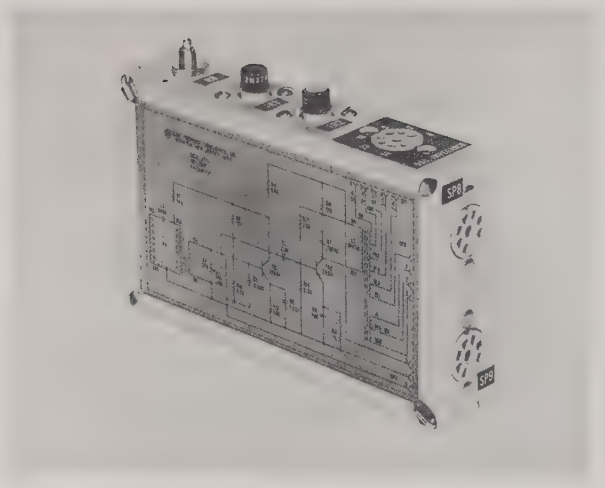


Figure 20.
View of Oscillator HB-13, 385 Subassembly.

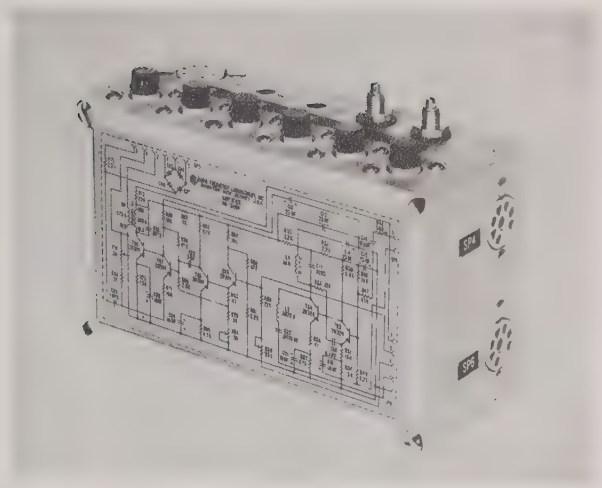


Figure 21.
View of Amplifier HB-13,400 Subassembly Showing Controls.

5 or 10-ohm output tap with the loading being accomplished with the resistor across the Hall contacts.

Calibration records on each range are provided for the probe and Gaussmeter supplied on each order. These data permit measurements to a greater accuracy than the direct reading accuracy. Probes can be interchanged between units without loss of the direct reading accuracy. For highest accuracy, the probe should be calibrated on the instrument with which it is used.

The sensitivity of a probe may be checked by measuring the AC voltage present at the output of the filter on pin 1 of P3 with 1000 gausses applied to the probe. The drive voltage across P8-1 and pin of P7 of the oscillator unit should be set to 0.1 volt. The signal output of the filter should be between .02 and .04 volt as measured between pins 1 and 5 of P3. Pin 5 is ground.

Amplifier - HB-13, 400 - The adjustment of the amplifier unit shown in Figure 21 consists of setting the input resistance of the amplifier to 2500 ohms and the setting of 3 gain controls. The input resistance of the amplifier is varied with the ADJ control R48. Place a high impedance vacuum tube voltmeter, such as a Model 300 Ballantine Voltmeter, between pin 1 of the filter at P3 and ground. With the probe plugged in and the RANGE SELECTOR S4 set at 10.0 gauss on red scale, adjust the upper COARSE zero control for .004 volt reading. Move the voltmeter to pin 5 of plug P4 on the amplifier subassembly and adjust R48 for a voltmeter reading of .002 volt. Repeat operation until the voltage at pin 5 of plug P4 is 1/2 the voltage at the filter output. As the multiplier resistor is 2500 ohms ±1%, the test operation sets the input to the amplifier to 2500 ohms as required to obtain the correct attenuation on the other gauss ranges.

The over-all sensitivity of the amplifier is adjusted by means of the potentiometers R64, R74 and the CALIBRATE control R76. The maximum sensitivity (CALIBRATE control in maximum clockwise position) is set by varying R74 and R59 on the top of the amplifier until .0045 volts on pin 1 of the filter brings the meter to full scale on the 100-gauss range (S4 on the red ranges). The input voltage is set up with the upper COARSE zero setting control. The potentiometers R74 and R59 are first set in the center and both shifted as required to maintain approximately the same gain in each transistor amplifier pair.

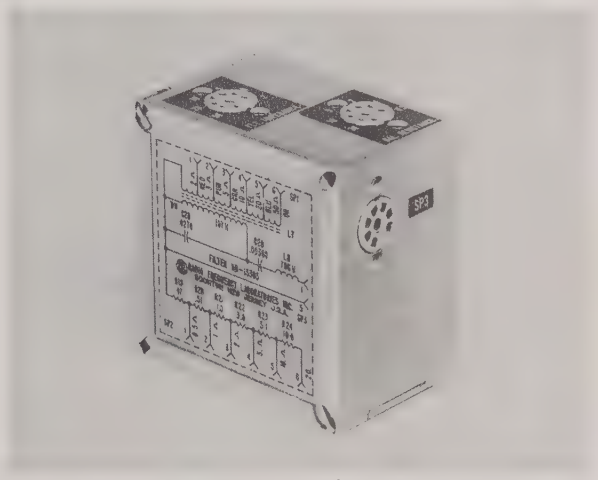


Figure 22.
Rear View of Filter HB-13, 365.

The 10:1 sensitivity ratio between the black and red scales of RANGE SELECTOR S4 is adjusted with potentiometer R58 on top the amplifier subassembly. This control is adjusted so that near full-scale reading is obtained for a 1000-gauss reference magnet on the 1000-gauss red range and also at 1000 gausses on the black range without a change of the CALIBRATE control R76. This adjustment will vary for different probes, as the setting of R58 is not entirely independent of the setting of R76.

NOTE

Shifting from red to black ranges or vice versa after calibrating with the reference magnet and CALIBRATE control may cause an error.

Table 3.
AC Voltage Chart

AC Line Supply

Note:
All measurements made with a vacuum tube voltmeter, such as the Model 300D Ballantine Voltmeter.

POINTS OF TEST	AC VOLTAGE
OSCILLATOR	
P9-3 to GND	.105
TR1 - B to GND	0.1
TR1 - C to GND	3.8
TR2 - B to GND	.045
TR2 - C to GND	4.
SP10-3 to SP10-1	0.1*
P8-3 to P8-5	.105
AMPLIFIER - 1.0 kilogauss range. 1000-gauss field thru probe, black ranges.	
P3-1 to GND	.066*
P4-5 to P4-1 (Not readable on Model 300D)	45 uv ±10% CALIBRATE control at max. CL
	110 uv ±10% CALIBRATE control at max. CCL
TR4 - C to GND	.0028
TR5 - C to GND	.003
TR6 - C to GND	.061
TR7 - C to GND	.021
TR8 - C to GND	2.4
P5-2 to GND	2.3

* Will vary with different probes.

Table 4.
DC Voltage Chart

AC Line Supply

Note: As measured with Simpson Model 260.

POINTS OF TEST	DC VOLTAGE
POWER SUPPLY - 115 v AC	
Power Supply Contacts	19 ±10%
BATTERY SUPPLY - 18 v DC	
OSCILLATOR	
P9-5 to GND	19 ±10%
TR1 - C to GND	8.9
TR1 - B to GND	1.45
TR1 - E to GND	1.42
TR2 - C to GND	17.
TR2 - B to GND	6.8
TR2 - E to GND	6.7
AMPLIFIER	
P6-7 to GND	19.
TR3 - C to GND	4.65
TR3 - B to GND	.78
TR3 - E to GND	.73
TR4 - C to GND	9.5
TR4 - B to GND	4.75
TR4 - E to GND	4.7
TR5 - C to GND	4.8
TR5 - B to GND	0.2
TR5 - E to GND	.15
TR6 - C to GND	8.7
TR6 - B to GND	4.9
TR6 - E to GND	4.8
TR7 - C to GND	5.6
TR7 - B to GND	.26
TR7 - E to GND	.15
TR8 - C to GND	17.3
TR8 - B to GND	5.2
TR8 - E to GND	5.1

Attenuator - A complete check of calibration requires reference magnets for the full-scale reading on each range. The attenuator resistance values are set so that after a calibration is performed on a reference magnet the other full-scale values will fall within ±2%. For maintenance purposes a partial check on the attenuator and probe would be to set the CALIBRATE control for full scale on the 1000-gauss red range with the 1000-gauss reference magnet, then measure this field on the 2000 and 5000-gauss ranges. No adjustment is provided in the attenuator, and a failure in the attenuator will normally require that the equipment be returned to the factory for repair. If a second probe is available, it can be used to check the first probe.

TROUBLE SHOOTING

If trouble develops in the Gaussmeter, follow the Trouble Shooting Chart of Table 5 and make the measurements shown in Tables 3 and 4 to locate the trouble.

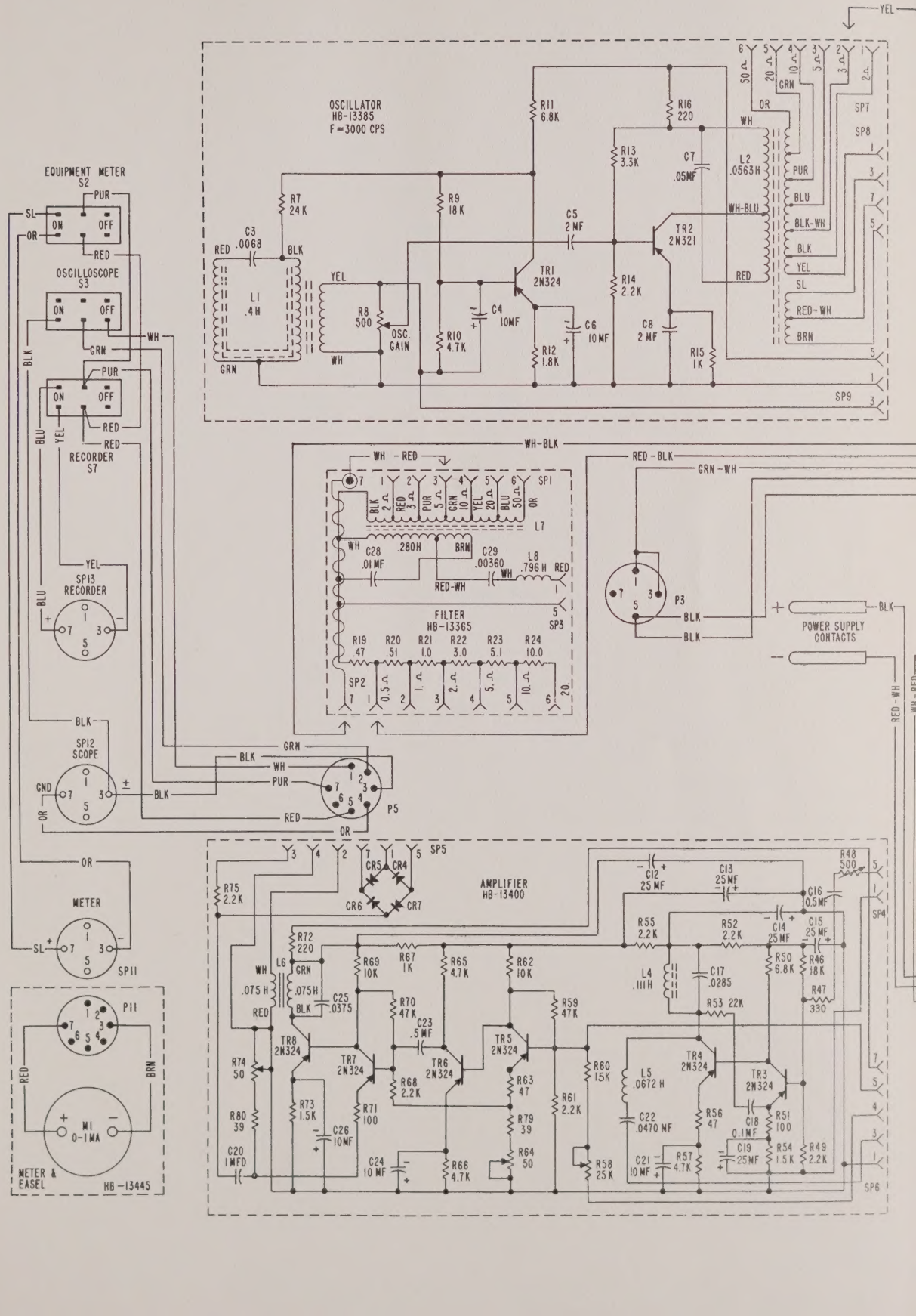
Circuit components and subassemblies are located through the use of Figures 20, 21 and 22 and the Schematic Wiring Diagram of Figure 23.

The modular form of the oscillator, the filter, and the amplifier makes their replacement an easier service policy than their repair within the equipment. The Gaussmeter is more quickly put back in service. For those who have more than one Gaussmeter, extra units may well be kept for immediate service while the faulty module is returned to RFL for repair.

Table 6 Replaceable Parts List is for your convenience in ordering replacements when necessary.

Table 5.
Trouble Shooting Chart

SYMPTON	CAUSE	REMEDY
Operation on 115 volts AC power. No pilot lamp.	Blown fuse, faulty plug P14.	Check for shorts in the power supply and replace fuse. Measure DC output of power supply to be 18 volts ±10%.
ZERO BAL. CONTROLS have little or no effect on zero on the 10-gauss ranges.	Open potential leads in probe E1 or open cable W1.	Check by shorting pins 5 and 7 of SP10 together and observing actions of controls. If no action, trouble shoot the amplifier. Replace faulty probe if controls operate the meter.
	Oscillator not functioning.	Check AC voltage between pins 1 and 3 of connector SP10 (E1 removed). If no voltage, trouble shoot the oscillator circuit and power supply.
	Open current leads in probe E1.	Measure with ohmmeter and replace probe E1.
OSCILLATOR		
No oscillator output voltage	Defective component in oscillator subassembly. Defective DC power supply circuit.	Trouble shoot oscillator circuit using Tables 3 and 4 for guides as to voltages. Trouble shoot power supply circuit.
AMPLIFIER		
Measure voltage of approximately .025 volt on pin 1 of P3 for 1000 gausses on probe.	Defective filter.	Remove filter connections and test with 50 ohms input impedance and 5000 ohms on output. (See Figure 23.) The step-up ratio is approximately 10. Bandwidth about 1000 cycles. Center frequency of 3000 cycles. Replace filter if defective.
No amplifier output indicated by meter.	Defective component in amplifier or meter circuit.	Signal trace circuit by applying 3000-cycle signal to input terminals P4-5 and P4-1 and use Tables 3 and 5 as voltage guides.


OSCILLATOR
HB-13385
F=3000 CPS
EQUIPMENT METER
S2
OSCILLOSCOPE
S3
RECORDER
S7
SPI3
RECORDER
SPI2
SCOPE
METER
SPII
PII
MI
0-1 MA
METER &
EASEL
HB-13445
FILTER
HB-13365
AMPLIFIER
HB-13400
POWER SUPPLY
CONTACTS
P3
P5
L1
.4 H
L2
.0563 H
L4
.111 H
L5
.0672 H
L6
.075 H
L7
.280 H
L8
.796 H
TR1
2N324
TR2
2N321
TR3
2N324
TR4
2N324
TR5
2N324
TR6
2N324
TR7
2N324
TR8
2N324
OSC.
GAIN
SP1
SP2
SP3
SP4
SP5
SP6
SP7
SP8
SP9
CR4
CR5
CR6
CR7
R1 2.2K
R2 24K
R3 .0068
R4 10MF
R5 2MF
R6 220
R7 24K
R8 500
R9 18K
R10 4.7K
R11 6.8K
R12 1.8K
R13 3.3K
R14 2.2K
R15 1K
R16 220
C3 .0068
C4 10MF
C5 2MF
C6 10MF
C7 .05MF
C8 2MF
R19 .47
R20 .51
R21 1.0
R22 3.0
R23 5.1
R24 10.0
C28 .01MF
C29 .00360
R45 2.2K
R46 18K
R47 330
R48 500
R49 2.2K
R50 6.8K
R51 100
R52 2.2K
R53 22K
R54 1.5K
R55 2.2K
R56 47
R57 4.7K
R58 25K
R59 47K
R60 15K
R61 2.2K
R62 10K
R63 47
R64 50
R65 4.7K
R66 4.7K
R67 1K
R68 2.2K
R69 10K
R70 47K
R71 100
R72 220
R73 1.5K
R74 50
R75 2.2K
R79 39
R80 39
C12 25MF
C13 25MF
C14 25MF
C15 25MF
C16 0.5MF
C17 .0285
C18 0.1MF
C19 25MF
C20 1MFD
C21 10MF
C22 .0470MF
C23 .5MF
C24 10MF
C25 .0375
C26 10MF
WH-BLK
WH-RED
RED-BLK
GRN-WH
RED-WH
BLK
WH
RED
GRN
YEL
BLU
PUR
BRN
OR
SL

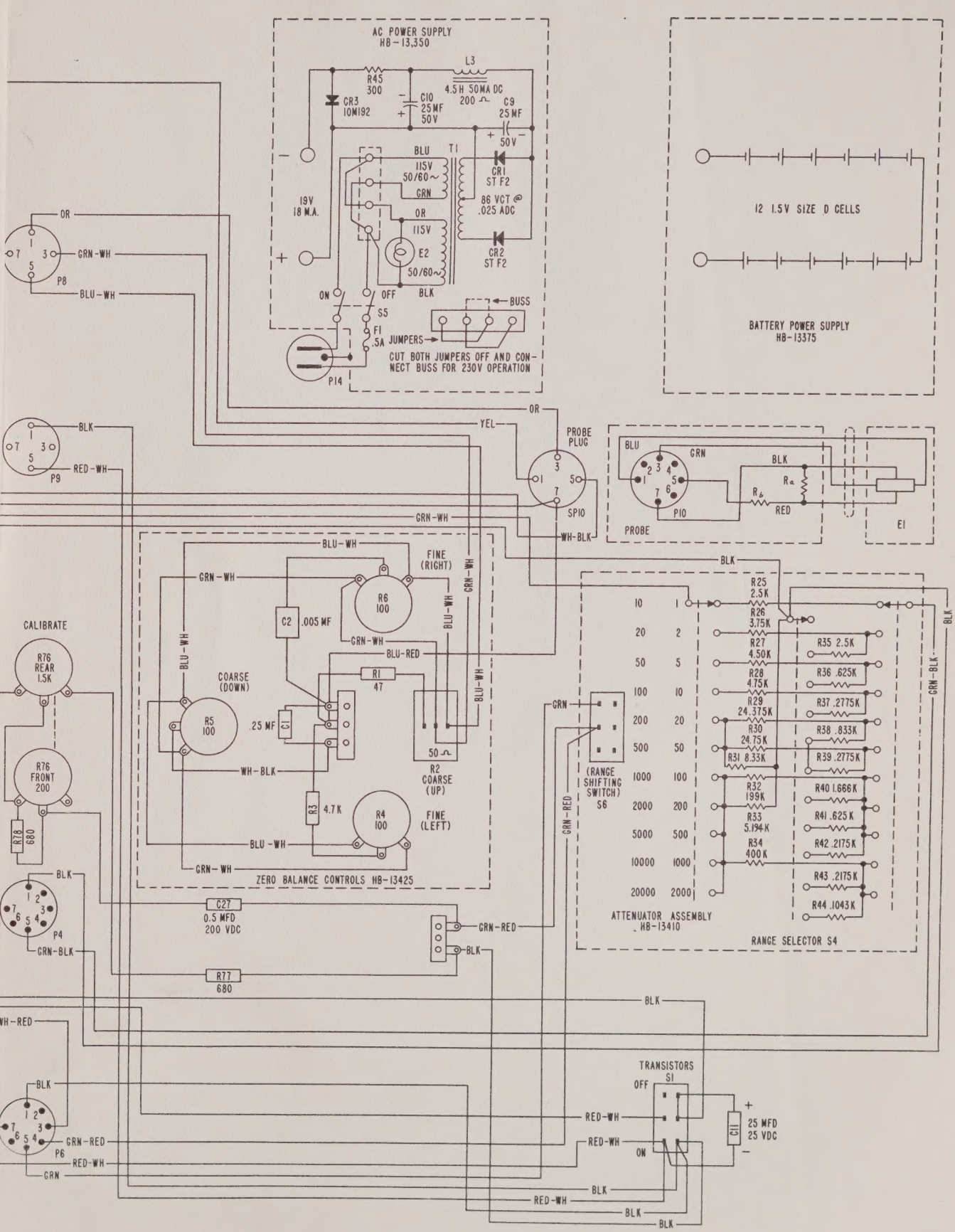
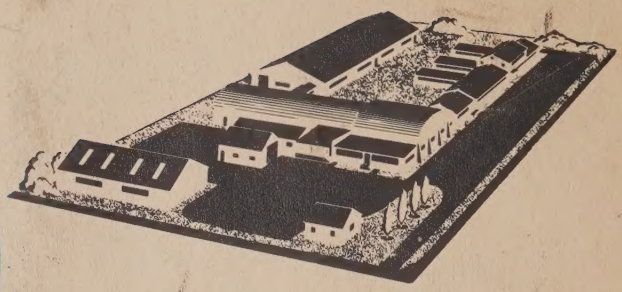


Figure 23. Schematic Wiring Diagram of Model 1890 Gaussmeter.



Warranty

The Model 1890 Gaussmeter carries a warranty of 12 months from date of delivery for replacement of any part, except probes, which fails during normal operation or service. A deficient part should be returned to the factory, shipping charges prepaid, for replacement f. o. b. Boonton, N. J.

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